Summary

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Synthetic polymers, also often called plastics, are the base materials for many new and beneficial products that meet our current and future needs. Many of the physical and chemical properties of plastics make them ideal materials for a wide variety of products and applications. However, because of their excellent mechanical properties, their increased use, mainly as packaging materials, leads to substantial environmental pollution. Although they are useful and desirable for many purposes, the indestructibility of petroleum-based plastics is a growing concern because of their accumulation in the environment. Polymer recycling has unfortunately not been successful, and it is estimated that only a few percent of the produced plastics are recycled worldwide. This is because recycling is expensive and the commingled waste is difficult to sort according to origin, color, and contained additives.

The plastics that are most widely used have poor biodegradability and may have lifetimes of hundreds of years when buried in typical solid-waste sites. Various approaches to render synthetic polymers degradable have been considered. In order to replace common synthetic thermoplastics by polymers of natural origin in commodity application, the biopolymers must be processable in existing, standard equipment and must have mechanical properties and stability comparable with those of the non-degradable thermoplastics. In addition to this, the biodegradability of the products may open avenues for increased use of farm commodities and other renewable resources. These materials could be used as substitutes for products made from non-renewable synthetic polymers. Degradable biopolymers can provide us with an increased flexibility in the design of materials, not only to suit desired product properties, but also to minimize any detrimental impact on the environment when the intended use of the product has ended.

In the last decades there has been significant interest in developing materials from blends of natural and synthetic polymers. These blends can be processed into useful disposable end-products that could alleviate the disposal problem by degrading in selective environments. Partially biodegradable polymers, obtained by blending biodegradable and non-biodegradable commercial polymers, can effectively reduce the volume of plastic waste by partial degradation. In many applications they can be more useful than completely biodegradable ones, due to the economic advantages and superior properties imparted by the commercial

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polymer used as a blending component. In order to obtain a cost-effective partly biodegradable plastic, starch-filled polyethylene (PE) is still the best alternative. Starch and PE blends are incompatible at a molecular level, however, and the resulting segregation often leads to poor performance. In order to overcome this drawback, either PE or starch should be modified. Nevertheless, the resulting products are not easily (read: fully) biodegradable.

In recent years great efforts have been made to produce suitable alternatives to replace non-degradable plastics with biodegradable polymers. Research into the development of biodegradable polymers derived from renewable resources gained considerable momentum in the 1990s, although the use of starch to produce biodegradable plastics began in the 1970s. In the temperature range from 90 °C to 180 °C, in the presence of plasticizers such as polyols or acrylamide, and under pressure and shear, starch can easily be molten. This allows starch to be processed by injection-molding, extrusion, and blow-molding, similarly to most synthetic thermoplastic polymers. Different extrusion processing conditions alter the transformation of the starch during the preparation of the thermoplastic starch resin, which ultimately affects the mechanical properties of the finished product.

Starch has been viewed as an important candidate in certain thermoplastic applications because of its known biodegradability, availability, and low cost. Agricultural crops provide different sources of biopolymers (starch, protein, and cellulose) which can readily be used to make biodegradable plastics. When biodegradability is required, thermoplastic starch (TPS) can be an alternative material for replacement of many petroleum-based products and it has gained much attention. Development of practical thermoplastic starch resins includes the addition of processing aids and plasticizers to aid gelatinization during processing, thus producing suitable mechanical properties in the finished product.

There are two approaches to overcome starch's drawbacks. One method is to blend starch with other biodegradable polymers. Another method to modify the properties of starch is the preparation of starch derivatives by replacing the hydrophilic –OH groups by hydrophobic groups, by esterification and etherification, for example. However, the prices of these modified starches are higher than those of other polymers. One of the simplest methods to reduce product hygroscopicity is the application of a coating with a paraffin-like material by spraying or other coating techniques.

With regard to the production of biodegradable thermoplastic material in an extruder, the base material consists of a natural polymer, a plasticizer, and an inorganic or organic compound such as a filler or fiber. The presence of fillers keeps the plasticizer in the material, and so the mechanical properties of the composite TPS are more stable than those in other biodegradable thermoplastic materials. Studies with biodegradable starch-based polymers have recently demonstrated that these materials have a range of properties, which make them suitable not only for agricultural films and coatings but also for use in several biomedical applications. These may range from bone plates and screws to drug delivery carriers and tissue engineering scaffolds. TPS is useful to make commercial articles either by injection-molding or film-blowing. TPS can be used in the form of biodegradable foams widely employed as cushioning materials for the protection of fragile products during transportation and handling. TPS films display low oxygen permeability and so also become attractive materials for food packaging.

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